Processes in Marginal Seas
and
ASIAEX Project Management

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Award Number: N0001401WR20044 (processes)
N0001401WR20093 (management)

LONG-TERM GOAL

My long-term goal is to enhance our understanding of coastal oceanography by means of applying simple dynamical theories to high-quality observations obtained in the field. My primary area of expertise is physical oceanography, but I also enjoy collaborating with biological, chemical, acoustical, and optical oceanographers to work on interdisciplinary problems. I collaborate frequently with numerical modelers to improve their predictive capabilities of Navy-relevant parameters in the littoral zone.

OBJECTIVES

The objective of these two closely-related grants is to plan and execute a multi-national oceanographic field program in the East and South China Seas to investigate how the complex littoral environment (i.e., its water column, boundary, sediment and sub-bottom structure and inhomogenities) affects the ray paths, mode structure, propagation loss, and temporal and spatial (both vertical and horizontal) coherence for low-to-intermediate frequency (50-4000 Hz) acoustic transmissions in shallow water

APPROACH

The objectives were addressed via an intensive field program in the East and South China Seas called the Asian Seas International Acoustics Experiment (ASIAEX). The ASIAEX main field program consisted of two distinct experiments; a reverberation experiment in the East China Sea with China and Korea, and a volume interaction experiment in the South China Sea with Taiwan and Singapore. The goal of the reverberation experiment was to *Develop models that can predict the mean reverberation level and fluctuations using measured environmental parameters*. The goal of the volume interaction experiment was *to understand acoustic propagation through shallow water when strong oceanic variability is present*.

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
30 SEP 2001		**00-00-2001 to 00-00-2001**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Processes in Marginal Seas and ASIAEX Project Management	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Department of Oceanography, Code OC/Ra,,Naval Postgraduate School,,Monterey,,CA, 93943**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT
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15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**6**	

Professors Ramp and Chiu both served two roles for ASIAEX, as principal investigators and project managers. As the International Science Coordinator and Associate Coordinator, they handled the logistics, political matters, research vessel clearances, and planning workshops for the entire program. They also participated in the East China Sea pilot study aboard the R/V ROGER REVELLE during spring 2000 and the South China Sea volume interaction experiment aboard the Taiwanese research vessel OCEAN RESEARCHER 1 during April 2001. Professor Ramp was one of the lead physical oceanographers for the U.S. team and Prof. Chiu one of the lead acousticians. Other key individuals involved in the SCS portion of the program (our most immediate collaborators) include James Lynch, Tim Duda, and Glen Gawarkiewicz of WHOI; Marshall Orr and Steve Wolf from NRL; and David Tang and Joe Wang from NTU.

WORK COMPLETED

Planning: Profs. Ramp and Chiu traveled to Beijing, Qingdao, and Hangzhou, People's Republic of China during late September-early October 2000 to continue planning activities for the ECS reverberation experiment. They also hosted a workshop at the Naval Postgraduate School during December 2000 to make final plans for the South China Sea volume interaction experiment. This was attended by investigators from Taiwan, NRL, and the Woods Hole Oceanographic Institution. A similar meeting was hosted by APL/UW in January to make final plans for the ECS reverberation experiment with the PRC. This meeting was attended by scientists from the PRC, Georgia Tech, Scripps Institution of Oceanography, and the University of Rhode Island. There were many tensions immediately prior to the ASIAEX field program due to the collision between a U.S. P3 aircraft and a Chinese fighter jet over the South China Sea, and also due to the breakdown of the primary U.S. research ship MELVILLE. These problems were overcome by constant communication, a great job by Scripps getting the ship repaired, and a preliminary trip to Taiwan just prior to the first cruise. In the end, only one cruise to the ECS was cancelled, the ECS bottom cores were obtained later from the Taiwanese ship OCEAN RESEARCHER 2, and all other cruises were completed successfully.

Analysis: The pilot study was carried out during 8 April to 2 May 2000 in the East China Sea. The actual study was confined to 15 days from 11 to 26 April withing a region bounded by 28-30°N and 126° 30' to 128°E. Most of the cruise time was spent on sub-bottom profiling, but one current meter mooring was successfully deployed and recovered and a few quality across-shelf CTD and ADCP sections were obtained. During this grant period, the pilot study data were analyzed and shared with the ECS team planning for the upcoming field program during spring 2001. The data proved quite useful for site selection and planning purposes. Work also continued on the outstanding data set from the Japan (East) Sea collected from the R/V ROGER REVELLE during June 1999 by Lynne Talley of SIO (CTD and hull-mounted ADCP data) and Carin Ashjian et al. of WHOI (towed CTD data from the video plankton recorder). These results were presented at a special session co-chaired by S. Ramp and L. Talley at the fall AGU meeting in San Francisco. A manuscript is in preparation.

Field Work: The central achievement of these grants during FY01 was the successful execution of the ASIAEX main field program in the South and East China Sea. Approximately 35 principal investigators from 18 major institutions participated in the work at sea. The resulting data set, collected over 108 days on eleven cruises aboard six research vessels in two marginal seas, is the largest and most comprehensive of its kind ever collected, and will serve to advance the state of the art in understanding acoustic propagation in shallow water. Due to space limitations, only the South China Sea moored array results will be highlighted here, as this was the principal investigator's primary scientific focus. For additional information on the ECS program, see the annual report by

Peter Dahl (APL/UW). For more information on the SCS SEASOAR cruises and acoustics work, see the annual reports by Gawarkiewicz (WHOI), Chiu (NPS), Lynch (WHOI) and Orr (NRL). The Low-Cost (LOCO) moorings are discussed in the annual report by Duda (WHOI).

RESULTS

The environmental, acoustics, LOCO, and Portable Ambient Noise Data Acquisition (PANDA) moorings were arrayed across the continental shelf and slope in the SCS between Taiwan and Dongsha Island (Figure 1). The data return was better than expected in this region of very heavy fishing activity, with just one of the environmental moorings (S1) being lost. Mooring S3 was also hit and cut in half, but the top half was recovered drifting by National Taiwan University (NTU) and the bottom half was dragged up successfully on the OR1 Leg III cruise. The moorings collected data from 21 April to 18 May 2001, set to sample rapidly (1-2 min intervals) to capture the full range of time scales from internal waves to the mesoscale. Without doubt, the most energetic motions observed were the strong, highly nonlinear internal waves or solitons, which were generated in the Luzon Strait and propagated WNW across the northeastern SCS to the ASIAEX region. These were the most energetic solitons ever observed anywhere in the world. The temperature record from mooring S7 on the 350 m isobath (Figure 2) shows that the thermocline was depressed all the way to the bottom when a strong wave passed by. The temperature at 100 m changed by 10•C from 18•C to over 28•C near 0800 on May 9. Several smaller waves followed behind the primary depression, in keeping with theoretical expectations. The largest solitons traveled with phase speeds of about 1 m s^{-1} (2 knots) and had orbital velocities exceeding 1.5 m s^{-1} horizontally and 0.5 m s^{-1} vertically. The transformation and dissipation processes acting upon these waves as they enter shallower water are unknown but can be well studied using this new data set. Their impact on acoustic propagation in the littoral zone will also be a prime area of study during the analysis phase of the program.

IMPACT/APPLICATION

The ASIAEX program is a follow-on to the New England Shelfbreak Primer experiment and as such will advance the state of the art in shallow water acoustic propagation prediction. The 2001 field program used more sophisticated acoustic sources and arrays, multiple towed vehicles, and alongshore as well as across-shore array configurations to better elucidate the subtle relationships between the water column variability, bottom and sub-bottom structure, and acoustic propagation loss. The ASIAEX analysis will lead to improved detection, location, identification, and targeting in the littoral zone.

TRANSITIONS

Profs. Ramp and Chiu have briefed the fleet twice so far on the impacts of the environment on East and South China Sea operations. They briefed CAPT Will Jordan and CDR James Hart of COMSUBPAC during February 2001 and ADM Sullivan and Dr. Schuster from N77 (ASW) during August 2001.

RELATED PROJECTS

None

PUBLICATIONS

1. Ramp, S. R., 2001. WORKSHOP REPORT: The Asian Seas International Acoustics Experiment (ASIAEX). Final planning meeting, Kailua Kona, Hawaii, June 21-23, 2000. *Naval Postgraduate School Technical Report* NPS-OC-01-001, 31 pp.

2. Chiu, C.-S., S. R. Ramp and J. F. Lynch, "The ASIAEX 2000 Preliminary Experiment in the East China Sea (ECS)," Proceedings of the 5th International Conference in Theoretical and Computational Acoustics, Beijing, China, 2001, in press.

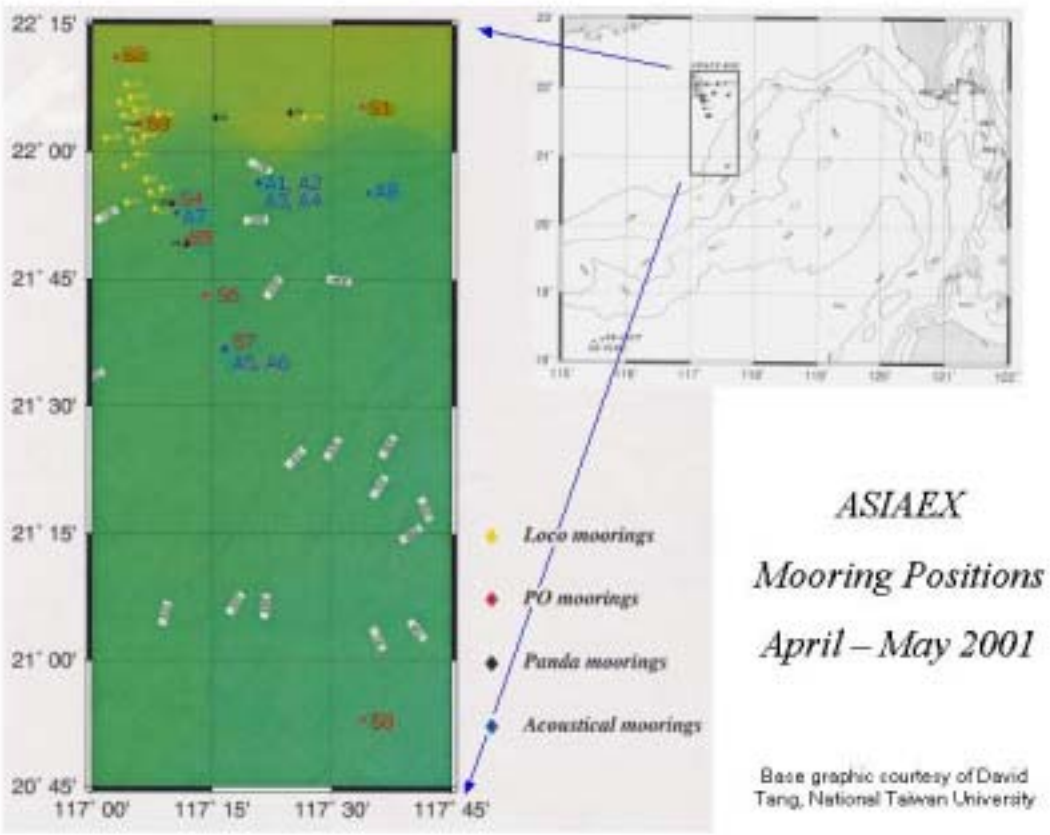

Figure 1. Location of the WHOI/NPS/NTU moored array deployed in the South China Sea during the ASIAEX experiment, April to May 2001. The red diamonds numbered S1 – S8 are the physical oceanography moorings and the blue diamonds numbers A1 – A8 are the acoustics moorings. The Low-cost (LOCO) moorings are indicated in yellow and the PANDA moorings in black.

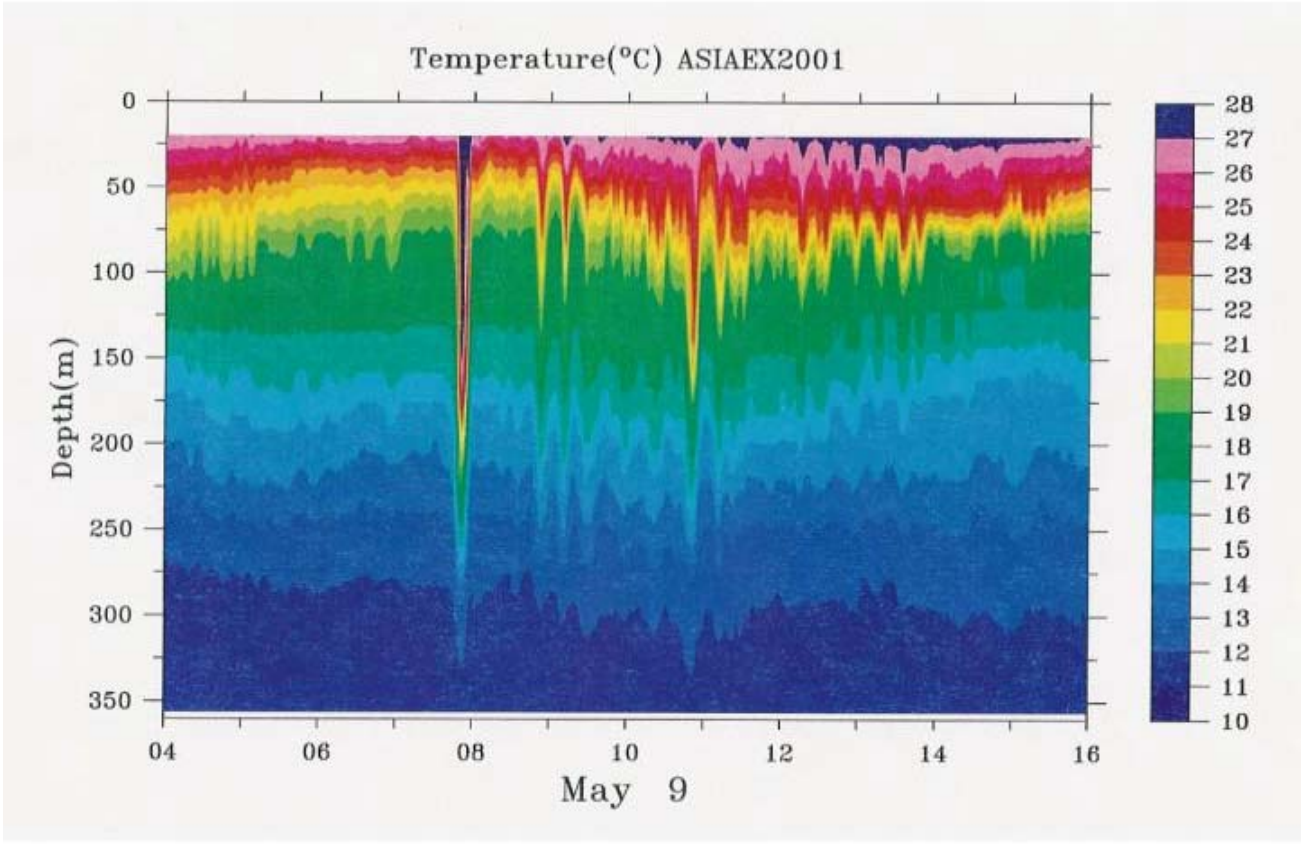

Figure 2. Temperature plot from ASIAEX mooring S7 (see location in Figure 1) from 0400 to 1600 hours on 9 May, 2001. The plot was constructed using data from several different kinds of instruments including microCATS, mini-Starmons, and Aanderaa current meters contributed to the experiment by NPS, WHOI, and NTU. This frame isolates one of the strongest nonlinear internal wave (soliton) events observed during the experiment, which occurred just prior to 0800 hours. Weaker, approximately rank-ordered waves follow along behind.